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Subject: Presentation added

Title: USE OF COMPUTED TOMOGRAPHY FOR CHARACTERIZING MATERIALS GROWN
TERRESTRIALLY AND IN MICROGRAVITY

Location: Huntsville, AL

Appropriate for peer communication: Yes

Description: Computed tomography (CT) is well known to the public because of its application as a technique for scanning the brain and other organs. The technique when used with x-rays or gamma rays as the source has many other applications, including the examination for internal failures in manufacturing processes, examination of rocks for prospecting purposes, and in this work the determination of compositions of solid samples grown within the microgravity materials science program. By rotating and translating the sample (contrary to the medical application where the source and detector are rotated around the patient), and collecting millions of counting sources, it is possible mathematically to re-construct the density of large volumes of materials. Provided the material is 100 % dense (i.e. zero porosity) and the relationship between density and composition is known, then it becomes possible to determine the compositions of materials throughout their volume. This has already been applied to space grown crystals where knowledge of the internal composition was needed to make optimum cuts of precious boules of material. The technique has also been applied to determine the density change on melting of various elements and compounds, data that are difficult to obtain with high precision in high melting point materials.

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Abstract: The purpose behind this work is to provide NASA Principal Investigators (PI) rapid information, non-destructively, about their samples. This information will be in the form of density values throughout the samples, especially within slices 1 mm high. With correct interpretation and good calibration, these values will enable the PI to obtain macro chemical compositional analysis for his/her samples. Alternatively, the technique will provide information about the porosity level and its distribution within the sample. Experience gained with a NASA MRD-sponsored Advanced Technology Development (ATD) project on this topic has brought the technique to a level of maturity at which it has become a viable characterization tool for many of the Materials Science PIs, but with equipment that could never be supported within their own facilities. The existing computed tomography (CT) facility at NASA's Kennedy Space Center (KSC) is ideally situated to furnish information rapidly and conveniently to PIs, particularly immediately before and after flight missions.

CT scanning is based on the ability to process millions of attenuation values resulting from the interaction of a high energy photon beam with a sample. By changing the direction of the incident beam, the algorithms can furnish the values for linear absorption coefficients in two dimensional space within the slice being irradiated. CT arrangements, including the one at KSC, typically use banks of many detectors, and both translate and rotate the sample. The technique has several important implications for use by the MRD PIs. First, the system is capable of examining several square feet of sample within the narrow height selected. This means that many samples, and of very

different types, can be examined simultaneously. Secondly, as the absorption values can be obtained in two dimensions, it becomes possible to obtain values while the samples are still encased. During the ATD project, satisfactory results were obtained for metallic samples while they were still within their protective Sample Ampoule Cartridge Assemblies (SACAs). Thus the technique is capable of measuring density within not only a fused silica ampoule, but also while within the encasing inconel cartridge. With the exception of edge effects, the work is quantitative. The CT system at KSC is being used with a cobalt-60 source, as compared with the normal x-ray sources employed. To our knowledge this feature is unique world wide, and has the advantage of producing a monochromatic beam with no preferential absorption as happens with the x-ray generated beams. So-called beam hardening effects are thus eliminated.

Experience has shown that continuous operation of the CT system with translation of 1mm between analytical slices can analyze fully a 72 mm length of sample within 24 hours. Complete data reduction and interpretation may take longer, but the information afforded is available very quickly, and before the PI's samples leave KSC. The implications of this in the Space Station era are tremendous. With the need for transport of many samples to and from ISS, rapid analysis is essential to provide the required information to the PI for any succeeding campaign on ISS. If it is necessary for the samples to be returned to the PI's facility prior to reliable scientific information being obtained, there are obvious implications to the planning of the experiments. CT will enable the PI to have an early assessment of the quality of the all of the samples, and with the analysis being done at KSC as soon samples are released from the shuttle, there is the possibility of rapidly obtaining important scientific data.

The proposed work here will be predominantly a service to current and future PIs and as such will "will lead to the definition or enhance the understanding of existing or potential flight experiment in material science." The ATD project referred to above was only funded for one year, and at less than a five-man month effort, and there is a pressing need for further interpretive work on several fields. First there is a need to determine the optimal technique for interpreting the histograms and statistics of the CT data. This is particularly true for compounds, be they solid solutions or two phase mixtures. In conjunction with this is the need for more standards, of high purity and particularly of metallographically well characterized structures. Examination of existing PI samples will be important preparation for the future ISS campaigns. Secondly there is a need to establish and implement the instrument requirements for improving both spatial and statistical resolution. Since the installation of the KSC CT instrument, there have been many improvements in CT technology particularly in detector efficiency, size and resolution. The specifications are now being sought for the procurement of the next generation of CT instrument at KSC; it is essential that MRD has an input into these specifications. Finally it should be noted that this project has implications to inject technology into the private sector. The ability to examine a product rapidly and non-destructively has obvious implications for industrial usage.